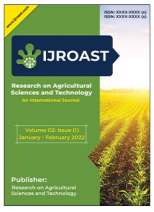
IJROAST

Research on Agricultural Sciences and Technology

Journal homepage: www.ijroast.com



Studies on pollinator diversity and managed bee pollination in moringa with Asiatic hive bee *Apis cerana indica*

Saravanan P.A[1*]., V.Ravichandran[1], and K.M.Kumaranag[2]

[1]Tapioca and Castor Research Station Tamil Nadu Agricultural University, Yethapur, Salem District - 636 119, Tamil Nadu, India
[2]AICRP (HB&P) PC Cell, IARI, New Delhi

ARTICLE INFO

Article history:
Received 1 January 2022
Received in revised form
12 January 2022
Accepted February 2022
Available online 26 February 2022

Key Words
Pollination
Moringa
Apis cerana indica

ABSTRACT

Moringa is a nutrient-rich, highly bee dependent vegetable crop in India. Several insects visit moringa flowers for nectar and pollen collection. The diversity studies revealed the visitation of thirteen Hymenopteran, seven Dipteran and seven Lepidopteran insects in moringa. Among these, honey bees play a major role in moringa pollination. Successful pollination ensures maximum fruit set and fruit quality of moringa. Hence, to study the pollination potential of the most common honey bee in South India, the Asiatic hive bee *Apis cerana indica* has been evaluated with four treatments. The findings showed, managed bee pollination with four Asian bee colonies per acre of moringa crop improved the fruit set (19.14 per cent) and fruit yield (11.40 per cent) compared to open pollination plots.

Introduction

Moringa is a multipurpose tropical tree native to India. It is being cultivated in many countries for its nutritious leaves, flowers, fruits, seeds and is mostly used for culinary purposes. In recent times, moringa has been considered as "superfood" to provide vital healthy nutrients to humans to fight against the Corona virus. Moringa flowers begin anthesis during the morning and anthers opens shortly after anthesis. The average fruit set in moringa is 10% and resulted from successful pollination by visiting bees. Successful pollination ensures maximum fruit set and fruit quality of moringa. More number flower visitors are attracted to moringa flowers. Honey bees, carpenter bees and other wild bees are considered important pollinators of moringa flowers. The present study has been taken up to assess the diversity of moringa pollinators and the role of managed Asian bee colonies in fruit set and fruit yield of moringa.

Methodology

Survey on the diversity of pollinators in moringa ecosystem

Survey of pollinators was conducted in two districts *viz*., Pallapatti of Karur district and Veppanthattai of Perambalur district during 2020-21. Five randomly selected moringa trees were marked in each garden. In each randomly selected tree, 5 inflorescences were selected for studying the pollinator's diversity. The natural pollinator visitation per five inflorescences per 5 min was observed in each of the five trees and final data expressed as pollinator count/ 25 inflorescences/ 5 min. This data was recorded every hour from 6 am to 6 pm. The population of insect visitors were recorded for a period of 10 days during peak flowering (after 20% of flowering). Flowering initiation and the duration of peak flowering were registered. Daily flower production on 25 randomly selected inflorescences, and the time of daily anthesis and anther dehiscence in relation to the prevailing weather were recorded.

Managed bee pollination experiment

The field experiments were carried out to study the pollination role of *Apis cerana indica* in a randomized block design with four treatments including control containing five replications. The experiment was taken up during the last week of February 2021 in a selected farmer's field in Veppanthattai and surrounding areas. Four bee colonies were placed in one-acre moringa field selected at Veppanthattai village, Perambalur Dist. and another two colonies were placed in a farmers field at Venbavur village and a control plot in Veppanthattai village. The nylon net sleeve

*Corresponding author: Tapioca and Castor Research Station, Tamil Nadu Agricultural University
Yethapur Salem District - 636 119, Tamil Nadu, India
E-mail: entosaravanan@gmail.com

cages were used to exclude the pollinators in randomly selected inflorescences (bud stage) from a moringa plot selected at Veppanthattai village. Observations were recorded periodically on flower visitors, bee visitation rate, no. of fruits formed per tree, fruit length (cm), fruit girth (cm), fruit weight (g) and total fruit weight per tree (kg). Colony growth parameters like sealed brood area (cm^2) and honey store area (cm^2) was also recorded in bee colonies and the data were statistically analysed and compared.

Results and Discussion

Survey on diversity of Pollinators in Moringa

A total of 27 species of pollinators were recorded in moringa ecosystem. Among them, thirteen belonged to Hymenoptera, seven to Diptera and seven to Lepidoptera. Among hymenopterans *Apis* group includes three insects namely *Apis cerana indica, Apis dorsata, A. florea* and Non *Apis* group includes ten insects which belongs to Vespidae, Scolidae, Sphecidae and Pompilidae . Among the Dipterans, seven insects belongs to Syrphidae, Sarcophigidae, Calliphoridae, Dolichopodidae and Muscidae. Among Lepidopterans seven insects belongs to Papilionidae, Pieridae, Nymphalidae, Hesperidae and Sphingidae (Table 1). Similarly, [1] recorded that *Scolia dubia* S. was the most frequent visitor (30.22%) of Drumstick inflorescence followed by Xylocopa virginica L. (21.24%) and other insects. [2] also reported 8 insect species visiting flowers of *M. concanensis nimmo* Linn and among them, little bee (A. florea) and black ant (Camponotus compressus F.) were the major pollinators of drumstick.

Table 1. List of pollinators and insect visitors recorded in moringa

Sl. No	Pollinators	Systematic position (Order : Family)	Role (N / P / N+P)
1	*Apis cerana indica*	Hymenoptera : Apidae	N+P
2	*A. dorsata*	Hymenoptera : Apidae	N+P
3	*A. florea*	Hymenoptera : Apidae	N+P
4	*Amegilla zonata*	Hymenoptera : Apidae	N+P
5	*Amegilla quadrifasciata*	Hymenoptera : Apidae	N+P
6	*Xylocopa* sp.	Hymenoptera : Apidae	N+P
7	*Polistes* sp.	Hymenoptera : Vespidae	N
8	*Vespa orientalis*	Hymenoptera : Vespidae	N
9	*Scolia* sp.	Hymenoptera : Scoliidae	N
10	*Sphex* sp.	Hymenoptera : Sphecidae	N
11	*Megachile* sp.	Hymenoptera : Megachilidae	N+P
12	*Pepsis* sp.	Hymenoptera : Pompilidae	N
13	*Halictus* sp.	Hymenoptera : Halictidae	N+P
14	*Episyrpus* sp.	Diptera : Syrphidae	N
15	*Sarcophaga* sp.	Diptera : Sarcophigidae	N
16	*Lucilia papuensis*	Diptera : Calliphoridae	N
17	*Eristalinus arvorum*	Diptera : Syrphidae	N
18	*Condylostylus* sp.	Diptera : Dolichopodidae	N
19	*C. occidentalis*	Diptera : Dolichopodidae	N
20	*Musca domestica*	Diptera : Muscidae	N
21	*Papilio polytes*	Lepidoptera : Papilionidae	N
22	*Pieris rapae*	Lepidoptera : Pieridae	N
23	*Tirumala limniace*	Lepidoptera : Nymphalidae	N
24	*Hypolimnas bolina*	Lepidoptera : Nymphalidae	N
25	*Danaus chrysippus*	Lepidoptera : Nymphalidae	N
26	*Orieus goloides*	Lepidoptera : Hesperidae	N
27	*Sphinx* sp.	Lepidoptera : Sphingidae	N

The pollinators were grouped into 4 groups, *Apis* sp., Non *Apis* Hymenopterans, Dipterans and Lepidopterans. Among them *Apis* sp. were high in number with a mean of 4.95/ 25 inflorescence/ 5 mins, followed by Non *Apis* Hymenopterans (3.37), Dipterans (1.56) and finally Lepidopterans (0.56). Among *Apis* Hymenopterans, *Apis cerana indica* was the major pollinator with a mean of 3.36/ 25 inflorescence/ 5 mins followed by *Apis dorsata* and *Apis florea*. In non *Apis* Hymenopterans, the major pollinator was *Amegilla cingulata* (1.51) followed by *Polistes* sp. and *Scolia* sp. Among the Dipteran pollinators, the major one was *Episyrpus* (0.36/ 25 inflorescence/ 5 mins) followed by *Lucilia papuensis* and *Sarcophaga* sp. Among the Lepidopterans, the major pollinator was skipper (0.13/ 25 inflorescence/ 5 mins) followed by *Papilio polistes* and *Danaus chrysippus*.

Pollinator visitation on 25 inflorescences for 5 min was observed every hour from 6 am to 6 pm for ten days during peak flowering which served as replications. The diversity index namely the Simpson's D was high (7.6) between 2 and 3 pm and the range was 3.3 to 7.6 throughout the day. Species richness (S) was more in 9-10 am and 1-2 pm. In general, the pollinator population was higher in the forenoon than in the afternoon. Nectar foragers spent more time than pollen foragers (Table 2).

Table 2. Population of pollinator groups at different days during moringa flowering

Pollinator groups / Days*	Pollinator population in 25 inflorescences / 5 min*									
	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
Apis Hymenopterans	3.73	6.18	7.09	6.91	3.64	4.09	3.73	4.18	4.09	4.09
Non *Apis* Hymenopterans	2.36	2.45	3.55	3.27	5.09	3.73	3.45	3.36	3.73	3.45
Dipterans	1.45	1.36	1.64	1.27	0.91	1.55	1.91	1.55	1.64	1.82
Lepidopterans	0.27	0.09	0.36	0.36	0.91	0.91	0.82	0.55	0.73	1.00
Diversity indices										
Species richness (S)	4	4	4	4	4	4	4	4	4	4
Simpson's D	2.82	2.21	2.43	2.32	2.73	3.12	3.26	2.95	3.07	3.26
Simpson's E	0.70	0.55	0.61	0.58	0.68	0.78	0.81	0.74	0.77	0.81
Shannon's H	1.14	0.96	1.05	1.02	1.14	1.23	1.26	1.19	1.22	1.26
Shannon's E	0.82	0.69	0.76	0.73	0.82	0.89	0.91	0.86	0.88	0.91

Managed bee pollination in moringa

The field experiments were conducted at different locations and the results revealed that the bee visitation rate / 5 inflorescences /3 min was maximum (6.02) in T1- four colonies /acre compared T2 – two colonies per acre (4.00) and T3 control (2.2). The fruit quality parameters like fruit length (54.30cm, 49.74 cm), fruit girth (6.38 cm, 6.12 cm) and fruit weight (126.4 g, 119.8g) were also significantly higher in fruits obtained from T1 and T2 fields respectively compared to T3 field (Table 3). Similarly, the number of fruit set /tree was significantly higher (128.2) in T1 followed by T2 (122.8) than T3 control field (107.6). Placing four A. *cerana indica* bee colonies per acre helped in a significant increase of 19.14 per cent fruit set respectively over the control. [3] also emphasised the role of honey bees and carpenter bees in moringa pollination. [4] documented various pollinators of moringa and revealed that honey bees were highly efficient pollinators compared to other non apis pollinators. The studies on colony growth parameters revealed that in all the colonies an increase in the area of sealed brood (23.02 to 34.63%) was noticed and similarly 128.65 to 169.51% increase in food storage area was also observed (Table 4).

Table 3. Effect of honeybee, *Apis cerana indica* pollination on yield and yield parameters of moringa

	Fruit length (cm)	Fruit girth (cm)	Individual fruit weight (g)	No. fruits /tree	Per cent increase over control (T3)	Total fruit weight (Kg/tree)	Bee visitation rate (No./5 inflorescence/3min.)
T1 – 4 bee colonies /acre	*54.30^{a}	6.38^{a}	126.4^{a}	128.2^{a}	19.14	16.20	6.02^{a}
T2 – 2 bee colonies /acre	49.74^{ab}	6.12^{ab}	119.8^{a}	122.8^{b}	14.13	14.71	4.00^{b}
T3 – Control (no managed bee colonies)	43.12^{b}	5.94^{b}	109.2^{b}	107.6^{c}	0	11.75	2.20^{c}
T4 – Pollinator exclusion#	0	0	0	0	-	0	0
SE (d)	2.97	0.29	5.36	6.43	-	-	0.29
CD (0.05)	6.48	0.63	11.69	14.0	-	-	0.64

*Mean of five replications; means followed by different letters within a column indicate significant differences (P<0.05)
Observations only from the bagged inflorescences

Table 4. Colony growth parameters of honey bee colonies placed in moringa orchards

Colony	Sealed brood area (cm²)					Honey and pollen store area (cm²)				
	22.2.2021	3.3.2021	12.3.2021	23.3.2021	Per cent increase	22.2.2021	3.3.2021	12.3.2021	23.3.2021	Per cent increase
T1 C1	70.3	82.3	85.8	90.4	28.59	14.8	21.4	29.6	38.5	160.14
T1C2	64.5	63.5	75.8	82	27.13	12.4	12.8	15.8	31.6	154.84
T1C3	65.6	70.4	78.2	88.3	34.60	16.4	21.8	28	44.2	169.51
T1C4	62.8	70.8	81.4	82.6	31.53	15.6	16.4	18.5	41.2	164.10
T2C1	58.2	63.6	68.2	71.6	23.02	16.2	15.4	18.5	38.6	138.27
T2C2	64.6	68.4	74.8	84.4	30.65	18.5	17.2	31.8	42.3	128.65

Conclusion:

Placing four Asian bee colonies per acre of moringa crop improved the fruit set (19.14 per cent) and fruit yield (11.40 percent) compared to open pollination plots.

Acknowledgement

The authors are grateful to ICAR for the financial support rendered through AICRP Honey bee and Pollinators project. The authors also wish to acknowledge the immense help received from the scholars whose articles are cited and included in the references of this manuscript.

Plate1. Diversity of Pollinators in Moringa flowers

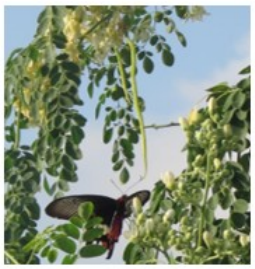
Apis dorsata

Apis cerana indica

Apis florea

Xylocopa sp.

Amegilla zonata



Papilio polytes

References

[1] Chukunda, F. A. 2016. Abundance and diversity of insect visitors to flower of moringa oleifera at forestry and environment arboretum. Research Journal of Forestry, 3(2): Pp 1-15.

[2] Palanichamy, P., Baskaran, S. and Mohandoss, A. (1995). Insect pollination of the moringa plant Moringa concanensis nimmo Linn. Environment and ecology. Kalyani, 13(1): Pp 47-51.

[3] Jyothi,P.V., Atluri J.B. and C.Subba Reddi. 1990. Pollination ecology of Moringa Oleifera. Proceedings of Indian Academy of Sciences.Vol.100 (1):33-42

[4] Somiya.C., Srinivasan M.R. and P.A.Saravanan.2018. Diversity of pollinators in Drumstick, Moringa oleifera Lam. Ecosystem. Madras Agriculture Journal. 105 (4-6):186-190.